CLOSED CIRCUIT TELEVISION REVIEW PROCEDURES
HIGH LEVEL SEWERSHED
BALTIMORE CITY PROJECT 1028

The information contained in this manual is not intended to address or account for all situations or circumstances encountered, rather it provides the user with general guidelines of the procedures followed during the review process of Closed Circuit Television Inspections in the High Level Sewershed.

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I. Introduction to Closed Circuit Televising (CCTV)

Closed Circuit Television (CCTV) inspection of sanitary sewer pipe is a thorough and effective method of determining the condition of each asset within a collection basin. The High Level Sewershed (HLSS) encompasses nearly one million linear feet of sewer pipe to be inspected by four subcontractors and nearly a dozen inspection crews. All sanitary sewers 8-inches in diameter and larger are required to be internally inspected via CCTV and the results documented for insertion into the existing City of Baltimore GIS database. The CCTV inspections may be used to evaluate the condition of the sewers, record defects that require rehabilitation or repair, identify potential sources of Inflow and Infiltration (I/I), and document unusual flow observations.

II. CCTV Inspection Process

Each inspection crew was comprised of a CCTV truck and operator, and a pipe cleaning truck. The inspection process begins with an attempt to "light clean" each pipe segment by feeding a pressurized hose back and forth through the pipe a minimum of three times. In cases where access is not possible for cleaning, an attempt to televise the pipe must be completed. Once the cleaning is completed, a camera, attached to a "tractor," is inserted into the pipe at a manhole. The camera proceeds along the length of the pipe segment recording the entire footage and observing the internal condition of the pipe between manhole structures. During the video inspection, the inspection crew shall properly document water level, debris levels, cracks, fractures, joints, infiltration, holes, and any other defects encountered using the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP) standards. Once the inspection is completed, the inspection is logged into the computer onboard the inspection truck. The data is then transferred to the Subcontractor's database for internal review before submittal to the HLSS Team for the official QC process. Subcontractors were tasked with submitting a copy of the monthly database and all corresponding videos to the QC team. The QC team would, subsequently, provide a report back to the subcontractor, which outlines any failed inspections. The QC response shall be returned to the subcontractor in a timely manner such that the subcontractor is able to quickly provide any corrections necessary to pass the failed inspection. Once an inspection passes the QC process, it is submitted to the client for final acceptance into their database.

All CCTV inspections shall be performed with strict adherence to the NASSCO PACP guidelines. All examples and definitions of defect coding used during the field inspections can be found within the NASSCO PACP Reference Manual Version 4.3.1. Standards used in the field and during the review process can also be found in this reference manual. The CCTV software chosen by the City of Baltimore as a standard medium for the HLSS Team was flexidata. Designed by Pipe Logics Inc., flexidata software uses a Microsoft Access database for data collection of the inspection operator's observations linked with the digital video footage captured in MPEG1 format. Each operator shall be trained on how to properly use flexidata and should be proficient in all of its features. Sample CCTV inspection reports, including the Pipe Graphic Report and the Tabular Report produced using flexidata, are provided at the end of this section as Appendix A and B respectively.

III. Quality Control Process

The City of Baltimore, under consent decree from the Environmental Protection Agency (EPA), has developed a strict Quality Assurance/Quality Control (QC) standard for their comprehensive wet weather program. In order to meet these standards, a thorough review process for the CCTV inspections must be completed before any data is submitted from the HLSS Team to the City. All of the QC review performed by the HLSS Team shall be completed according to NASSCO PACP guidelines. Each QC reviewer shall be trained and certified before beginning the review process. The following is a step-by-step description of the HLSS Team's procedures and how these procedures changed and adapted over the course of the project.

Monthly Submittals & QC Database

Each CCTV subcontractor shall submit monthly field data to the QC team. The data shall include the flexidata database and MPEG1 video files. An Access QC database is created for each monthly submittal for each subcontractor. Once the QC database is synchronized with the overall CCTV database, Baltimore's GIS database and the PACP's quick score query, a form is created with pull-down menus, auto-populated fields and comment boxes. An example of the QC form is shown in Figure 1:

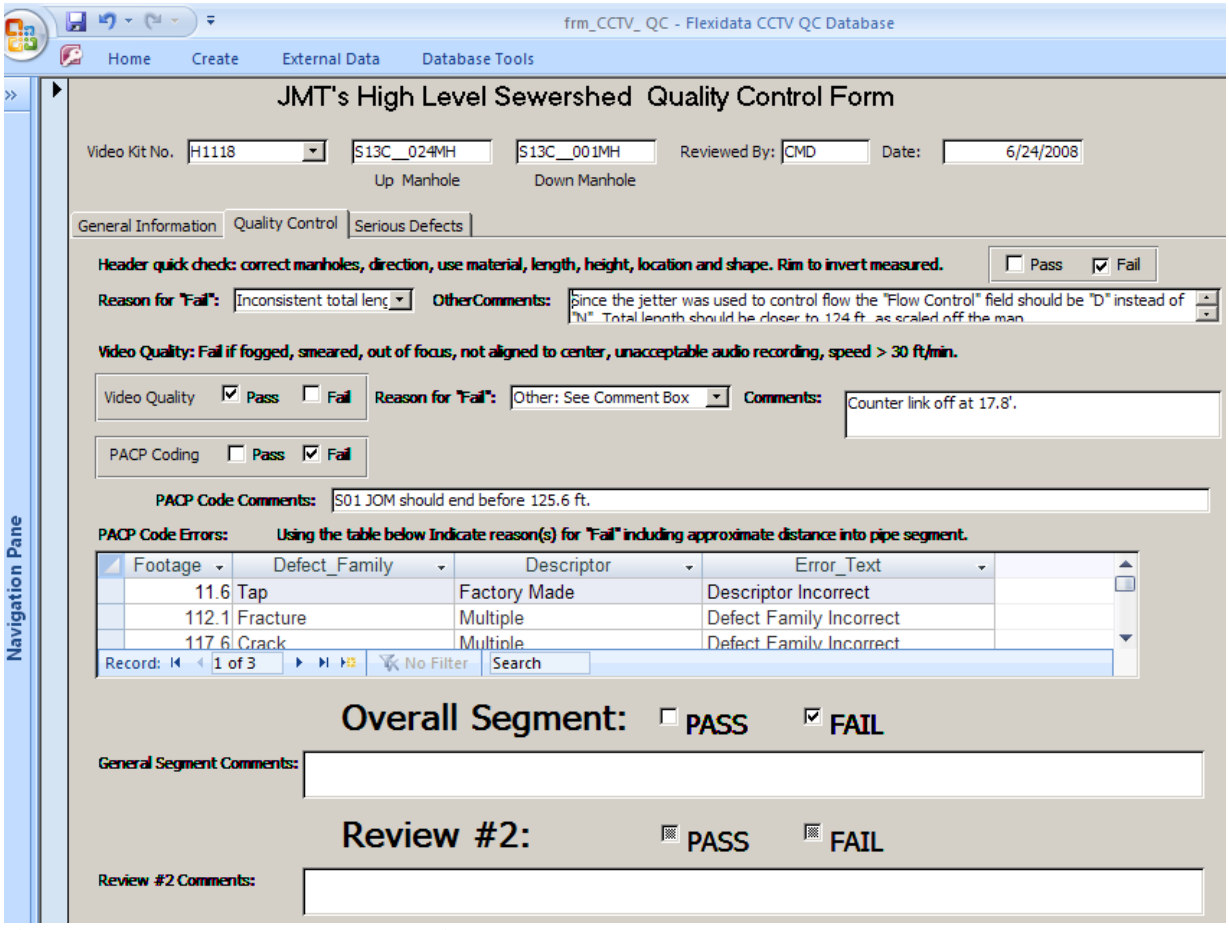

Figure 1 – HLSS Team CCTV QC Review Form

The main CCTV QC form is divided into six separate sections:

- General Information (Unique Inspection ID, Manhole IDs, Date, Reviewer's Initials)
- Header Check
- Video Quality
- PACP Coding Errors
- General Comments
- Review #2 Comments

From this form, a report is generated and submitted back to the subcontractor for corrections to the submitted CCTV database.

Detailed QC Process

1.) **Unmatched Manhole ID** – A list of Unmatched Manhole IDs is compiled from a query when the flexidata database is synchronized with the City of Baltimore's GIS database. If the upstream and downstream manholes of an inspection record do not match those identified within the GIS database, the inspection automatically fails the QC process. These errors shall be fixed by the HLSS Team, rather than the CCTV subcontractor, in order to save time and prevent multiple resubmissions from the subcontractors for the same QC failure.

2.) **PACP Quick Score Query**– The majority of the QC review process has been designed around the PACP QC Grading System. Every defect is graded on a scale according to a priority ranking. The scale ranges from one to five with a "1" being a minor defect (e.g. attached deposits) and a "5" being the most severe (e.g. collapsed pipe). The PACP Quick Score is a 4-digit score that shows the two highest defect grades coded in the segment and then counts the number of defects with this value. The Quick Score Query was developed by the HLSS Team to scan the CCTV database for Structural Quick Scores beginning with grades "4" or "5". It generates a list of key segments that must be reviewed during the QC process because they have at least one structural defect with a grade of "4" or "5". This review serves not only to generate a priority defect report for severely damaged pipe segments to be repaired immediately, but it also helps to find critical errors made by incorrect coding of sewer pipe segments that are not defective.

3.) **Header Checks** – This check is a verification of the GIS database, to ensure that the header matches the data in GIS. Figure 2 is a flexidata Header screen capture showing is the key data fields that are checked during this step of the QC process.

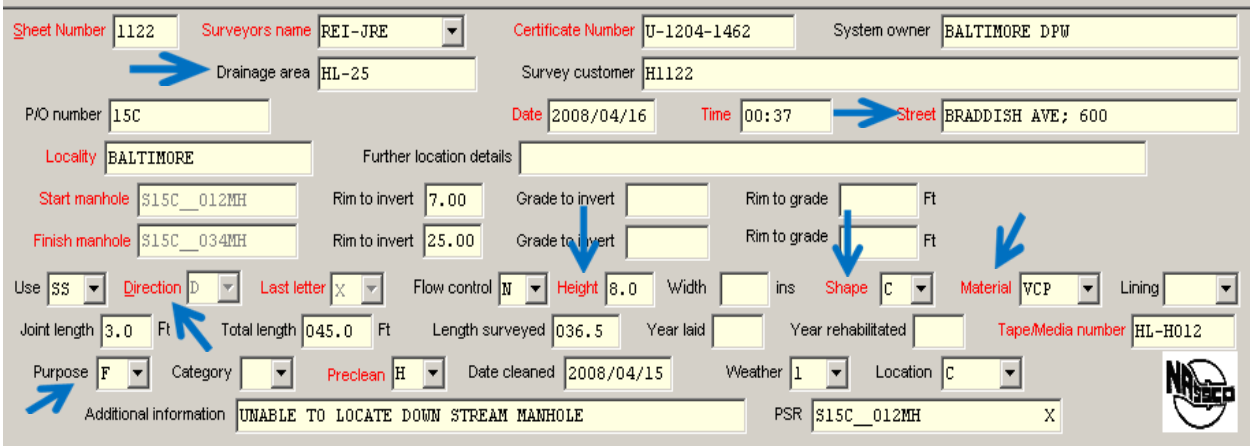

Figure 2 – flexidata Header

Drainage Area is the name given to the flow monitoring sub-basin during the comprehensive monitoring period. An accurate street address helps City maintenance crews find the defect locations on a map. The direction assists in identifying the distance from either the upstream or downstream manhole to the defect. Height, shape and material provide the City with information needed to determine the proper materials for any emergency rehabilitation necessary. This information also helps determine the potential cost for future, larger-scale rehabilitation projects. The Purpose defines the reason for the inspection taking place. During this phase of the project, each of these inspections represents a "Routine Assessment" of the existing pipe's condition; however, additional CCTV inspections may be required during the dye testing phase. The Additional Information box is also important, as it shall be used to provide information on reverse inspections and explanations for incomplete inspections.

4.) **Video Quality Check** – Each video shall be subjected to QC review for completeness, audio quality and video quality. Examples of typical video quality failures include:

- Not complete from beginning to end
- Too dark
- Too much light causing a reflection of the pipe
- Flow greater than PACP acceptable standards for more than twenty feet
- No audio
- Poor audio – Could not understand audio, profanity, etc.

Figures 3 through 6 are examples of some defective video images that will not pass QC review.

Figure 3 – Image Too Dark – Low Lighting

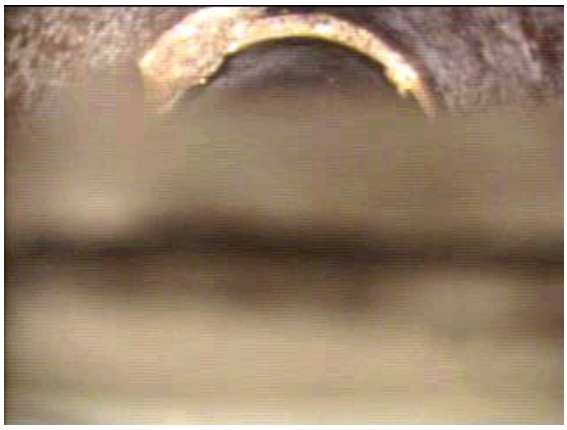

Figure 4 – Flow Level too high

Figure 5 – Corrupt Video File

Figure 6 – Image Too Foggy or Smudged

5.) **PACP Coding Check** – Each inspection that has been flagged for review shall be checked for coding errors. The HLSS Team mandates that an inspection may have no more than five "minor" coding mistakes per one hundred linear feet. If a single "major" defect has been missed, the inspection is designated as "failed" and is then returned to the subcontractor for editing. Examples of major defects may include broken pipe, holes, deformation, and collapse. If a minor defect is found missing or incorrectly coded in the CCTV database, the PACP Error Coding Table, as shown in Figure 7, should be completed within the QC review database. This table allows the QC reviewer to note the footage where the coding was incorrect during the inspection, the defect family and descriptor, and what the error was in the coding. This table shall be included in the QC report so the subcontractor can edit the CCTV database and resubmit the corrected database to the HLSS Team.

PACP Code Errors: Using the table below Indicate reason(s) for "Fail" including approximate distance into pipe segment.

Footage	Defect_Family	Descriptor	Error_Text
191	Tap	Defective	Incorrect & Missing Remark
222.5	Tap	Defective	Incorrect & Missing Remark
225	Crack	Circumferential	Omitted Observation

Record: 1 of 8 No Filter Search

Figure 7 – PACP Error Coding Table

6.) **Priority Emergency Repairs** – The reviewer shall determine whether the defect was scored properly and whether the severity warrants an immediate repair/rehabilitation of the pipe segment. If the defect must be repaired, a Priority or Emergency Repair email shall be sent to the City depending on the severity of the defect. The email should include a map of the area where the defect was found and a picture of the defect taken during the CCTV inspection. The defect shall be logged into a tracking spreadsheet and kept for further reference.

7.) **Incomplete/Exception Inspection List –** A complete inspection includes only those inspections that span the entire pipe between two manhole structures or between one manhole and the dead end of a pipe. If the inspector fails to complete a pipe segment in one direction, an attempt shall be made in the reverse direction. The inspection should be added to the Incomplete List if the inspector fails to do a reverse inspection and/or fails to complete all but twenty or less feet of the total pipe segment. Incomplete inspections are designated as "failed" during the QC review and shall be submitted to the subcontractor with the corresponding QC Report. The sewer basin is divided into plats and any pipe segment that has not been attempted is placed on the incomplete list after 75% of the plat has been completed. Initially, many incomplete inspections were noted; however, since the City has approved pricing for heavy cleaning, incomplete inspections should be promptly designated as "failed" and, subsequently, returned to the subcontractor for heavy cleaning, root cutting, etc. Several exceptions may be made for some incomplete inspections, including the following examples:

- No truck access to the manhole
- Specialty cleaning is necessary to complete the segment
- Structural defects prohibit completion from both directions
- One or more of the manholes cannot be located or are buried

Once an exception is made and the data that has been compiled for the incomplete pipe segment, the inspection record is submitted as non-core data to the City with a detailed explanation as to why it is an Exception. After the subcontractor has inspected as much of the pipe segment as possible it becomes an Exception. Once this is completed, the segment is removed from the Incomplete List. If a pipe segment could not be attempted for a particular reason, a "Filler Record" should be created with an explanation as to why an attempt was not made.

8.) **GIS Edits** – The thorough CCTV inspection process has revealed many structures within the High Level Sewershed that do not currently exist in the GIS database; and, therefore, need to be added to accurately represent the existing collection system. When a new structure is found in the field, a temporary manhole ID must be created using the existing plat number (e.g. S09MM1), the inspection crew letter (e.g. T), a sequential number (e.g. 02) per each plat, and the structure type (e.g. MH), (e.g. the resultant ID would be S09MM1T02MH). During the QC review, the new structure shall be located and dimensioned on the appropriate section of pipe, and submitted to

the GIS department for insertion into the GIS database. The hard copy record of the structure location should be filed by Plat ID for future reference. Once the GIS team has added the new structure to the GIS database, a permanent ID must be assigned to replace the temporary ID. The flexidata database ID must be edited to reflect the new permanent ID and to match the GIS database.

CCTV inspections shall also be used to confirm or deny GIS connectivity issues. If discrepancies are found between field conditions and the GIS a map is marked up with reference to the inspection record and video and submitted to the HLSS GIS Team.

Internal Tracking Process

Each inspection submitted to the HLSS Team shall be tracked on a plat-by-plat basis through the QC Plat-Tracking Database. The database allows the QC Team to accurately gauge the inspection progress in each plat. It provides the number of pipe segments that exist, have been attempted, passed, and failed, as well as the percentage of the segments that have been completed and delivered to the City. This tool shall be used to quickly determine how many sewer pipes remain in each plat. The QC reviewer can generate a priority field work list for each of the subconsultants. This list reduces the number of work options for the field crews as well as places a focus on finalizing each plat for the "Non-Core Delivery" and, eventually, the "Core Delivery".

Improvements to the QC Process

Throughout the duration of the High Level Sewershed Study, changes were made to the QC process to streamline the time spent on each task and improve efficiency and quality on the final product. As previously detailed, the QC reviewer would note failed inspections for a number of reasons and compile a report for the subcontractor to follow and make the appropriate edits. This was originally done, because the reviewer had a limited copy of the flexidata software. Using the limited version, the reviewer was only able to view the inspection records but did not have the ability to change any of the header inputs and inspection codes for each inspection. Only the subcontractors had the ability to make revisions to the internal data in the database. As a result, there was a significant delay in receiving edited data back from the subcontractor. Often, the edits were not completed in a timely manner; and, subsequently, the inspection data was not able to be submitted to the City. These individual delays developed into gaps in the plat completion process, as observed through the QC Plat-Tracking Database. This was also noted in the GIS tracking published map, which showed a visual progression of the field inspections. The HLSS Team completed research into the flexidata databases and found, through MS Access, that they could make simple changes within the header section on a number of the fields where mistakes were forcing the inspections to be failed. Once the changes were made by the HLSS Team's QC reviewer, queries were re-run for each database and the number of failures decreased exponentially. This also reduced the number of edits required by the subcontractor.

It became evident, through a series of events, that the number of failed inspections due to coding errors was rather extreme. Early in the review process the number of revisions sent back to the CCTV subcontractor averaged 80% of the total monthly database. As a result of the refinement

of the QC process and an increase in the subcontractor's inspection quality, the number of failed inspections was reduced.

IV. CCTV Non-Core Submittal Process

Once the QC review has been completed for each segment, the data is ready to be submitted to the City through a "Non-Core" delivery process. The non-core data includes all information that has been collected through the field investigation process. The raw data includes all of the reviewed and passed inspections and corresponding videos from each sub consultant, packaged together in one comprehensive bi-weekly deliverable. The package is put together using guidelines provided by the City's BaSES Manual. The appropriate data is delivered on a single portable hard drive along with manhole inspection data, survey data, smoke testing data and dye testing data. A final "CCTV QC4" checklist is completed before all of the information is uploaded to the portable hard drive. The checklist is the final review step before the data is officially turned over to the City for their review and approval. The list of CCTV information included in each submittal is as follows:

- Supplemental Database
- Merged flexidata Databases from each subconsultant
- Non-Core Transmittal Letter
- List of Retractions
- Video Folder containing the all the corresponding videos

Supplemental Database

The Supplemental Database containing the GIS_Feature_LookUp table which is a comprehensive list of sewer segments being delivered to the City as non-core data. The table includes a delivery ID for each sewer inspection submitted, which is a code that represents the City's Project Contract number paired up with the submission number (i.e., 1028-021i). The "Unique ID" is the pipe's survey number given when the inspection is performed and represents which truck and subcontractor performed the inspection. This Unique ID is paired with the "Sewer ID" which is represented by the upstream manhole's ID. The database name where the inspection originated is provided in the table as well along with the overall pipe structural and O&M scores and ordinal position. The pipe scores are based on the defects observed and coded during the investigation. The score is an average determined for the pipe's condition throughout the entire stretch between manholes. "Structural Levels" are based upon the over physical condition of the pipe itself. It is a measure of cracks, holes, breaks, offsets, fractures and collapses. "OM Levels" are a measure of the interior conditions of the structure where proper maintenance can enhance the operation of the system. These include: Debris, roots, sags, water levels, grease, rocks, rags and vermin, which are all things scheduled maintenance can prevent.

Merged flexidata Databases

Each subcontractor delivers monthly flexidata database submittals for HLSS Team review. Edits are made to those submittals and based on CCTV QC comments a finalized monthly database replaces the original submittal. The monthly databases are merged together into a centralized database for every pipe that has been inspected by each subcontractor. Merged databases are also created for historical investigations that were performed during and/or after rehabilitation projects are completed within the High Level Sewershed. The merged databases unify the collection of inspection databases into one file and make the non-core submittal easier to prepare. An updated merged flexidata database is provided to the City for each subconsultant for each non-core delivery.

Non-Core Transmittal Letter

A letter of transmittal is sent with every delivery to outline what is included in the submission. It details the number of sewer inspections from each subcontractor, the number of manhole inspections, smoke tests, dye tests and surveys included on the portable hard drive. It details the date and time of the submission of non-core data to the City.

List of Retractions

The non-core delivery includes a list of sewer segment retractions and their explanations. The list of retractions is made when several factors occur. When a pipe is submitted to the City that couldn't be entirely completed, it is sometimes later replaced by a complete inspection. The list includes the Unique ID and Sewer ID of inspection being replaced and a brief explanation of why the retraction is necessary. This ensures the City has the same inspection on file for each sewer segment that the HLSS Team is using during their assessment of the pipe.

QC – 4 Checklist

This is the final check performed by the HLSS Team to ensure that everything is included in the delivery package. It runs through a list of procedures and follows the instructions outlined in the BaSES Manual for completion. Figure 7 shows the HLSS QC-4 Checklist. Once everything is completed on the list the submittal is packaged onto the portable hard drive and hand delivered to the City for their review and acceptance of the data. Once the data is approved the appropriate inspection data can then begin being process for the GIS core delivery.

HL CCTV QC 4 Checklist

Delivery ID: _____ # records in Lookup Table: _____

Review Date: _____ # of videos being Delivered: _____

QC 4 Reviewer: _____ # of Inspections being Delivered: _____

Item #	Action	Checked?	Item	Comments
1	Database		Check tables & fields listed in BaSES Chapter 6. See page 6-19.	Run "Check Fields" Module and delete "..._Fix" tables from delivery DBs at the end
2	Database		Are all the proper fields included in the submitted database(s)?	Run "CleanUp Fields" module
3	Database		All extra fields deleted from database.	Run "CleanUp Fields" module
4	Database		Databases named properly (Ex. HL-0901-ADS.mdb)	Rename and put in delivery folder and on EHD
5	Database		Proper number of Delivery IDs populated for each subcontractor	
6	Clients Table		CL_Name = Baltimore City	Autopopulated by UpdateFields-DeliveryDBs module
7	Project Table		Proj_Contractor = 3 character code of the CCTV Contractor	Autopopulated by UpdateFields-DeliveryDBs module
8	Project Table		Proj_Location = HL	Autopopulated by UpdateFields-DeliveryDBs module
9	Project Table		Proj_Title = Name of the flexidata database	Check T_Projects table for each DB
10	Pipes Table		P_Catchment = HL-## (Sewershed & subsewershed codes)	Check appropriate "..._fix" table, note any edits because they will need made in the appropriate monthly DB
11	Pipes Table		P_PlaceName should be "BALTIMORE"	Autopopulated by UpdateFields-DeliveryDBs module
12	Pipes Table		P_PLR = Upstream MH ID	
13	Pipes Table		P_Use = SS	Autopopulated by UpdateFields-DeliveryDBs module
14	Pipes Table		P_ScheduledLength should not be blank. Scale from GIS as needed.	Check appropriate "..._fix" table, note any edits because they will need made in the appropriate monthly DB
15	Video Table		Vid_JobNumber = Tile of the starting node	Spot check
16	Video Table		Vid_Frungs to be populated with delivery ID. Examples: 1028-001r1 & 1028-019i	Run "updateDeliveryID" module to populate
17	Video Table		Look for very small values in the Vid_LengthSurveyed field	
18	Video Table		Check Vid_Comments field for refrence to Sheet Number for reversals	Check appropriate "..._fix" table, note any edits because they will need made in the appropriate monthly DB
19	Video Table		Include extra comment in Vid_Comments field for submitted exceptions.	Log comments in exceptions comment spreadsheet.
20	Video Table		Vid_SystemOwner = "BALTIMORE CITY DPW"	Autopopulated by UpdateFields-DeliveryDBs module
21	Video Table		Vid_Purpose = "F"	Autopopulated by UpdateFields-DeliveryDBs module
22	Video Table		Vid_DVSFile & Vid_DVSRef fields can not be blank.	Use T_Video_Survey Check query
23	Scores Table		SC_ScoredOn = Date scores were populated	Use T_Scores Check query
24	Scores Table		Make sure score values have been populated by Flexidata. No blanks.	
25	Look-up table		Look-up table DB should be named HL-yymm-Lookup.mdb (ex. HL-0901-Lookup.mdb) and located in Supplemental Database Folder	
26	Look-up table		Look up table should be named GIS_Feature_LookUp & contain fields listed on pg. 6-18 of BaSES.	
27	Look-up table		Check the lookup table database for non-reversal duplicates.	
28	Look-up table		Scores properly populated in Look-up table with Scoring Tool Output from Peer	Use "CalcScores_Lookup" module
29	Look-up table		Do all scores of 5 in the look-up table make sense? Check video. Elevate scores where needed.	Use engineering judgement & the following data sources: tbl_CollapsedDeformation_fix in each delivery DB (filter by delivery ID) and the Priority_Emergency_repair.xls (in defect tracking folder).
30	Hard drive		Make sure all videos & inspections for each segment are included in the DVS folder.	Run batch file to check for differences if need be.
31	Hard drive		Delete old Delivery Folders from EHD (ex. 1028-021i & 1028-022i)	
32	Hard drive		Open video in flexidata to ensure the video is not a corrupted file & has audio.	
33	Hard drive		Look for lined pipe when opening videos	
34	Hard drive		Check MH IDs on video splash screen and comment if different than DB	Add to MHIDEdits.xls if need be.
35	Video Table		Vid_Comment field will need appended with "Vid ID Wrong" for inspections where MH IDs on video do not match DB.	Run module to populate with inspections listed in MH ID Edits spreadhseet.
36	Hard drive		Put videos in the DATA folder on hard drive, each in separate project folder.	Pg 6-16 of BaSES. Copy DBs to EHD when final
37	Hard drive		1028-Non-Core_Retractions.xlsx spreadsheet updated and copied into Retractions folder on EHD.	
38	Transmittal		PDF Transmittal should include delivery ID & device being used for delivery	
39	Transmittal		PDF Transmittal should include length of pipe surveyed & number of records.	
40	Transmittal		PDF Transmittal should list plats that are being delivered.	
41	Transmittal		PDF Transmittal should list any issues and/or exceptions that may affect data quality process.	
42	Database		Compact and Repair delivery DBs before submittal.	
43	Database		Delete modules, forms, queries, etc. from delivery DBs and Lookup DB	
44	Database		Make sure all the fields are un-hidden in the tables.	

Figure 7 – QC-4 Spreadsheet